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U.S. Predator Operations – Update

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Bibliography: This information for this paper has been extracted primarily from a paper titled "The Use of Predator in Bosnia – Lessons Learned" produced by Peter Wiedemann of the Joint Strategic UAV Program Management Office in May 1997. The information from that paper has been updated to March 1999.

Summary: The U.S. Predator unmanned aerial vehicle system produced by General Atomics Aeronautical Systems, Inc. has completed three extended operational deployments and has recently commenced a fourth deployment in support of United Nations and American operations in Bosnia-Herzegovina. The Predator system has also recently commenced a deployment to a site in Kuwait. Predator provides operational commanders and their intelligence staffs with valuable and timely live imagery and imagery derived intelligence, often not available from any other source. Through the conduct of these deployments, the operational concept to make best use of the real time reconnaissance capability of Predator has continued to evolve. This paper will provide an overview of the system and a description of the operations with a focus on the changes that have occurred since the original deployment in July 1995.

Background: The experiences of military commanders in operation Desert Storm, who were frequently unable to get timely imagery intelligence on targets of interest, caused them to recognize the requirement for a high capability theater controlled unmanned tactical reconnaissance system. With the advent of the innovative and highly streamlined procurement mechanism call Advanced Concept Technology Demonstration (ACTD) which allows the U.S. government to rapidly field equipment in emerging technologies, the Predator system was born. The Medium Altitude Endurance UAV or Tier II ACTD program was initiated in January 1994 to meet the following requirements:

- Continuous coverage (24 hrs per day, 7 days per week) coverage over a target 500 nautical miles from the operating base.
- Real-time communication with the air vehicle beyond line of sight (LOS) range.
- Capability to detect and identify typical mobile targets from a slant range of at least 15,000 feet, the requirement designed to allow the system to operate out of range of small arms and shoulder fired weapons.
- Minimum service ceiling of 25,000 feet to allow operation over elevated terrain while maintaining 15,000 feet slant range.
- Provide a visible light sensor capable of producing motion imagery to allow the controller to acquire and monitor targets for extended periods of time
- Provide an infrared sensor capable of producing motion imagery of targets at night or of targets with significant thermal signatures.
- Synthetic Aperture Radar (SAR) to allow imaging through clouds day and night.
- Operate under the control of the theater commander
- Provide the capability for rapid deployment using C-130 or larger airlift vehicles and to be operational within 6 hours of arrival at the operational site.
- Produce releasable imagery at low classification levels to allow maximum dissemination and usage.

The ACTD procurement, which virtually eliminated the lengthy analysis and review processes which cause standard procurements to take many years, allowed the Predator program to move ahead rapidly and meet the following milestones:

- Contract award — Jan 94
- First flight — Jul 94
- Training start — Oct 94
- JTF-6 Demo — Feb - Mar 95
  - Border Patrol/Counter Narcotics
- Roving Sands — Apr - May 95
- JSOC Demo — Jun 95
  - Special Forces
- NOMAD VIGIL — Jul – Oct 95
  - JTF Provide Promise
  - Operation Deliberate Force
- USCS — Oct – Nov 95
  - Coordinated ops with P-3
  - Border Patrol/Counter Narcotics
- COMTUEX — Nov 95
  - Maritime Operations
- SSN Demo — May – June 96
  - Control from submerged SSN
- Production Program Begins — Sep 96
- NOMAD ENDEAVOR — Mar 96 – Dec 97
  - Joint Endeavor
  - Joint Guard
- NOMAD ENDEAVOR — Mar 98 – Nov 98
  - Joint Guard
  - Eagle Eye
- JOINT FORGE — Mar 99 – pres
- SW ASIA — Jan 99 – pres.

Paper presented at the RTO SCI Symposium on "Warfare Automation: Procedures and Techniques for Unmanned Vehicles", held in Ankara, Turkey, 26-28 April 1999 and published in RTO MP-44.

System Configuration: The original concept of operations for the Predator system called for only "light" exploitation of imagery at the GCS with the resulting still imagery to be directly disseminated to an intelligence (INTEL) facility at the Joint Task Force (JTF) Headquarters. The INTEL facility would then perform the traditional formal exploitation of the still images and generate formal intelligence reports. This was determined to be impractical and the decision was made to co-locate an exploitation facility with the Predator System. The facility, now used routinely in all deployments, is known as the Rapid Exploitation and Dissemination (RED) cell. It houses intelligence analysts and workstations in a portable van.

System Equipment: The operationally deployed Predator system consists of equipment provided by the contractor and equipment provided the U.S. government. While the system configuration varies depending on the operational site, the following listing identifies the basic equipment used in the support of Bosnian operations.

Contractor supplied equipment consists of:
- Predator aircraft equipped with:
  - EO/IR visual sensor system
  - Synthetic Aperture Radar (SAR)
  - Ku band satellite datalink
- Ground Control Station configured with:
  - dual pilot and payload operator (PPO) control stations
  - Data Exploitation and Mission Planning Consoles (DEMPC)
  - SAR Workstations
  - Ku band satellite datalink module
- Ground Data Terminal (GDT) to support the C-band LOS data link
- Ground Support Equipment for operation and maintenance of the system
- Additionally, the contractor supplies personnel to provide technical support for the maintenance and logistics of the system.

Government supplied equipment consists of:
- Trojan Spirit
  - half used for Ku band control of the Predator
  - half used for the dissemination of intelligence data from the RED Cell
- RED Cell
- Secure satellite communication with the Combined Air Operations Center (CAOC) and the Joint Analysis Center (JAC) used for:
  - transmission of still images and reports
  - tasking

System Operation / Product Dissemination: The Predator system components function as follows:
- GCS
  - performs mission planning on DEMPC
  - controls Predator aircraft through PPO console
    - C-band LOS datalink
    - Ku band satellite datalink
  - controls EO/IR payload through PPO console
    - C-band LOS datalink
    - Ku band satellite datalink
  - controls SAR through SAR Workstation
    - Ku band satellite datalink
  - sends motion video overlaid with selected telemetry to RED Cell
  - grabs and sends SAR frames to RED Cell
- RED Cell
  - receives tasking from command centers via secure satellite network
  - adds narration to motion video from GCS
  - compresses video and audio using MPEG-2
  - disseminates compressed information to command centers and other users via VSAT
  - exploits still frame images from video and SAR and disseminates with reports via secure satellite network
- JAC Molesworth
  - routes compressed information to other users
  - stores images and reports
- Command Centers
  - receive and decompress video and audio for review
  - receive and review still images and reports
  - provides tasking to Predator (and other) operational sites
- Other users
  - receive and review selected product

Mission Tasking: Field commanders initiate the tasking process by providing intelligence requests that are converted into target lists and Essential Elements of Information (EEIs). These are combined, validated, and assigned to the appropriate platforms (i.e. Predator) at the CAOC. The target assignments and airspace allocations are integrated into the Air Tasking Message (ATM) which is routed to the airspace users

Mission Planning: Upon receiving the ATM, the RED Cell analysts perform detailed research on each target by accessing data bases containing earlier imagery of the target areas. This is done to provide the payload operators with the necessary information to facilitate target recognition and acquisition. The geo-coordinates of the targets are also verified. The information is then passed to the mission planners in the GCS who are simultaneously acquiring weather and other pertinent data. The mission planner starts with a digital terrain map of the transit and target areas. Keep out and threat areas are plotted and each target (referred to as a Collection Point) is plotted. Next waypoints are plotted and each waypoint is identified with altitude, airspeed, and several other characteristics including sensor parameters for Collection Points. The mission planners also create an emergency plan to direct the aircraft back

to the base in the case of datalink communications failure.

The mission planning software then provides a series of automated checks to verify the viability of the mission plan. The parameters that are checked include fuel usage, climb performance, terrain avoidance, continuity of satellite communications, etc.

Mission Execution: The Predator aircraft, properly configured for the selected mission, is launched at the appropriate time by a pilot "flying" from the cockpit-like PPO console and controlling the aircraft directly through the C-band LOS data link. The aircraft autopilot system enhances handling stability. The pilot uses a TV camera in the nose as the "pilot's eye" for viewing what is in front of the aircraft.

Although the Predator can be programmed to collect intelligence on targets in a fully autonomous, this is not the usual practice. The payload operator typically controls the optical sensors manually through his/her own PPO console. Imagery from the selected optical sensor appears on the monitor in front of the payload operator. The imagery is also sent from the GCS to the VSAT system for dissemination and to the RED Cell for frame grabbing and annotation.

SAR intelligence is always collected in the pre-programmed mode and is supported only by the Ku band satellite data link, not by the C-band LOS data link. The "waterfall" display appears on the SAR workstations in the GCS. 1000 by 1000 (pixel) areas can be frame grabbed and sent to the RED Cell for exploitation and export.

Mission Application: The system has been used effectively in support of the following missions in Bosnia:

- Humanitarian Assistance Monitoring
- Troop Protection
- Target Coordinates
- Search and Rescue
- Pre and Post Strike Surveillance (End-to-end support of the Look-Shoot-Look Model)
- Dayton Accord Compliance Monitoring
- Burial Sites Monitoring
- Peacekeeping

Sensor Usage: The following paragraphs describe the Predator sensors and their utilization during deployment.

Daylight TV Cameras include a color TV camera with a continuous 16-160 mm zoom capability and another identical color TV camera with a fixed 955 mm spotter lens. The color motion video produced by these sensors is the most intuitive intelligence product and is the product of choice by most of the operational commanders. The value of the motion video is obvious for tracking moving targets of interest but it was also the first choice for observing stationary targets. Additionally, although the intelligence community has long preferred black and white imagery, the color product is the product of choice for operational commanders and has proven to have value in recognizing earth that had been disturbed, in rapidly identifying the blue NATO vehicles, and other applications. The daylight TV cameras are only marginally useful at night and only in a relatively well lit environment.

The Forward-looking Infrared Camera produces the same motion video but without color. It is the sensor of choice in darkness or visibility conditions that reduce the effectiveness of the daylight TV cameras. The FLIR sensor is equipped with three fields of view, 11 mm, 70 mm, and 280 mm, and is equipped with a 2X doubler that can be applied to each field of view. Unfortunately, the sensitivity of the Platinum Silicide (PtSi) detector would only support the use of the doubler against "hot" targets. This problem has been addressed and will be explained later.

The Synthetic Aperture Radar (SAR), first used in the second deployment, produces imagery that are the least intuitive in that it is still images only, the images are monochromatic, and present an "unfamiliar" look. Trained SAR analysts must view SAR images. Therefore, operational commanders would select SAR as a last option only when weather conditions made the other sensors ineffective. Trained analysts actually liked the Predator SAR product.

Mission Effectiveness: The tables below indicate the continual improvement in mission effectiveness over the four years of deployment in support of the Bosnian operations.

Flight Hours

	year	total	mission	%
Nomad Vigil	1995	850.1	756.3	89%
Nomad Endeavor	1996	1444.0	1351.2	94%
Joint Guard I	1997	1482.5	1432.8	97%
Joint Guard II	1998	867.9	831.9	96%

Flights

	year	total	mission	%
Nomad Vigil	1995	130	79	61%
Nomad	1996	253	167	66%
Joint Guard I	1997	211	156	74%
Joint Guard II	1998	131	100	76%

Of the missions attempted, approximately 70% were completed with 20% aborted due to weather and 10% due to other factors. It is important to note, however, that many of the aborted missions were partially complete since intelligence was successfully collected on

one or more targets prior to the abort. The majority of the weather aborts occurred during the severe winter months in central Europe where icing conditions are prevalent. With the "all weather" SAR sensor aboard, it became apparent that the Predator would have to be modified to be able to withstand the rigors of winter weather. This will be discussed later.

Lessons Learned / Changes Made: The remarkable new capability provided by the Predator surveillance and reconnaissance system brought about a number of changes in the way that the operational and intelligence organizations do business. The result was an evolution in organizational relationships, tactics, doctrine, methods and overall battlefield management that remains one of the most profound aspects of the Bosnian operations.

With the original concept of operations, the only intended product of the Predator system was still images and textual reports to be distributed only to the intelligence analysis facility at JTF headquarters. Through the experience of the Bosnian operations, several user classes emerged. The availability of narrated motion video has generated a new set of users with operational commanders and their personnel choosing to view the motion imagery rather than waiting for still imagery and intelligence briefings.

At the beginning of the first deployment, the standard cycle for the Air Tasking Order was 72 hours. That is the time from initial receipt of intelligence requests to the time that the intelligence platform was collecting intelligence over those targets was an average of 72 hours. This time decreased to 48 hours and continued to decrease until retasking during the mission became the norm. As imagery is collected early in a mission, delivered rapidly to the users and analyzed, often the mission target assignments were changed to increase time over some targets, add new targets and delete other targets. Some of the commanders found that by being in direct communication with the payload operator in the GCS, that they could instantly retask the Predator. This phenomenon could lead to direct remote control of the payload.

The reliance of commanders on the real-time video has tended to erode the traditional role of the intelligence analyst. The commanders have noted, however, that they can misinterpret or be misled by what they see (i.e. they are more likely to be diverted by a decoy than a trained analyst). Additionally, the trained analyst is more inclined to want more in-depth information and more trend information on a target than the commander. Consequently, there is an ongoing realignment in the traditional roles and responsibilities as the forces learn to maximize the benefit of this new "virtual presence" in the battlefield that the Predator provides.

System Improvements: There have been a number of improvements to the Predator that resulted directly from the deployed experiences. These include:

- Improved system support
- Improved digitization and compression for the Ku band satellite data link.
- Enhancements to Mission Planner and Flight software.
- Improvements to the IR sensors
- Development of a de-icing system.

De-icing system –

The laminar flow wing on Predator which allows the aircraft to have extremely long endurance is extremely susceptible to the disruption of airflow as would be introduced by the accumulation of even small to moderate ice on the wings. In order to cope with the rigors of winter weather in Central Europe, a de-icing system was developed for Predator. After considering several alternatives, the resulting design contained the following elements:

- heated camera lens
- heated pitot/static system
- ice sensor
- "weeping wing" method of distributing an ethyl glycol mixture over the wing and tail surfaces to prevent / remove the accumulation of ice.
- The addition of a turbo-charged engine to offset the additional weight and loss of lift associated with the de-ice equipment.

Improved IR sensor –

The limitations of the use of the 2X doubler lens with the existing Platinum Silicide (PtSi) detector on the FLIR sensor caused a search for a new sensor. The sensor has been replaced with a new sensor that uses an Indium Antimonide (InSb) detector that is approximately ten times more sensitive than the PtSi detector. Although the new InSb detector is half the size of the PtSi detector (256X256 vs. 512X512), the significant increase in MRTD sensitivity has made the 2X doubler lens a valuable asset. Resolution and image interpretation improvements are dramatic.

ATC Voice Relay –

As the mission environment in Bosnia transitioned from wartime to peacekeeping, the concerns about integrating the Predator unmanned aircraft into the mix of commercial and military air traffic increased. One of the major limitations of unmanned air vehicles is that communications with air controllers was accomplished over the telephone to controllers who were often a great distance from the GCS site rather than a manned aircraft whose pilot communicates directly via radio with the local controller. The solution was to incorporate a voice relay system in the aircraft that allows the pilot in the GCS to use the standard "push to talk" method

of communication to talk directly to controllers in the area where the aircraft is operating. The system uses the Ku band satellite data link to relay the communications from the radio in the aircraft to the pilot in the GCS.

Mode IV IFF –

Also to enhance the ability to integrate Predator into the mix of commercial and military air traffic, a standard military Mode IV IFF system is being integrated into the Predator system.

Sensor Upgrade –

The optical sensors are also being upgraded with autofocus and autotrack features.

Summary: As the U.S. government continues to gain deployed experience with the Predator system, there has been on ongoing evolution in the way the battlefield is managed. Additionally, there is a new awareness of requirements to make this and future systems more responsive to the needs of the operational commanders. As new system requirements have been identified for Predator, General Atomics Aeronautical Systems, Inc. has been able to meet customer needs.